parsnip diseases in massachusetts

Forking and Sorehead

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PARSNIP DISEASES IN MASSACHUSETTS

EMIL F. GUBA*

INTRODUCTION

This contribution is intended as a guide to the identification and control of parsnip diseases. All of the known parsnip diseases in the general area of Massachusetts are described and illustrated. Obviously, some of the information is familiar knowledge; some of it is taken from the author's observations and research.

The parasitic diseases of parsnip in Massachusetts presently can be said to be better understood than formerly. The non-parasitic diseases remain as problems of further research by specialists in this professional area of study, in spite of the author's objective studies for some degree of clarification.

GENERAL CONSIDERATIONS

The parsnip is an important vegetable crop on some farms in Massachusetts. The largest acreages are in Essex County, ranging from 100-150 acres; the second largest in Middlesex County with 80-100 acres, and following are Hampden with 25-45 acres, Hampshire with 10-20 acres, and Worcester with 10-15 acres. Bristol County averages about 10 acres, Barnstable and Dukes together, Berkshire and Franklin, each 5-8 acres. State-wide parsnip acreage runs around 275-300 acres. Production (8 year average 1949-1956 inclusive) was 145,000 half-bushel boxes (22 lbs. each) or 32,000 cwt., value $263,000. In 1957, production was about 182,000 half-bushel boxes, or 40,000 cwt., value $380,000; in 1958, about 200,000 half-bushel boxes or 44,000 cwt., value $440,000. The supply of local parsnips in the winter is sometimes short enough to cause shipments into Massachusetts from distant outside points. The figures show some trend toward increased production in Massachusetts.

The marketing season extends from August to the following May. Prepackaging is the accepted method of marketing, and uniform white parsnips in film bags in consumer outlets are a pleasing sight. Attractiveness is advanced by slender, moderate-sized roots, clean white color, and freedom from blemishes. Broad-shouldered varieties are not acceptable. The change from the half-bushel box to film-packaged parsnips has required changes in the variety and cultural practices to meet the high standard of quality required of packaged parsnips. Actually, these changes with respect to varieties and methods of culture have contributed to greater disease control on the farm. Example of change is culture on raised beds which increases the depth of the soil for good root growth, improved root form and length, and which provides better drainage of water, an important

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factor in disease control. The change to the Model variety of parsnip has substantially reduced losses from forked roots. Model also has some resistance to the *Itersonilia* canker disease.

Disease can be serious in parsnip culture. Roots affected with disease and non-parasitic abnormalities are discarded in packing the roots for market and channeled elsewhere for food for hogs and cattle. Only fancy roots are marketed. There is no other grade. Thus, the loss from disease is essentially on the farms and familiar only to the farmers.

If the parsnip crop is overwintered for the spring harvest, there is more loss from disease. There is less disease among roots harvested in the late summer than in the autumn season. Excessive and persisting wet weather, poorly drained land, and persisting moist stagnant air in the area of culture are important factors contributing to parasitic diseases.

Only a limited investment in the crop to counteract disease is possible. This investment would apply essentially to some modification in culture to overcome particular conditions contributing to pathogenic diseases and non-parasitic growth defects of the roots, to the change to other varieties with less tendency to trouble, and even to the occasional chemical treatment of the land for the control of pathogenic organisms such as the root-knot nematode.

ASPECTS OF DISEASE

Parsnip diseases, like all agricultural crop diseases, fall into two distinct categories; parasitic diseases, or those caused by parasitic organisms such as molds, bacteria, viruses, and nematodes; non-parasitic diseases, or those where no parasite is involved, but instead some environmental or cultural factor adverse to the normal healthy growth of the plant. In either case, the result is injury, detrimental change, or death of the plant or a portion of it.

Most of the parsnip diseases in Massachusetts are caused by fungi. A fungus is comprised of the nourishing part called spawn or mycelium, and the reproductive part, the fructifications and spores. The mycelium lives and grows in the host plant tissue to the disadvantage of the plant. This association is a state of parasitism and the result is disease. Green plants make food from raw materials in the soil and in the air. The parasitic fungi lack the green chlorophyll for this process and thus nourish themselves as parasites on their green host plants.

The fungus also includes fruiting bodies, or spores, for its reproduction and spread. There are thousands of parasitic fungi, and they differ chiefly by the characters of fructifications and spores when seen by the microscope. Two of the fungi causing spotting and blighting of parsnip foliage appear in Figures 1 and 2. The drawings show how these two fungi appear and differ. The leaf spot and blight of parsnip caused by the fungus *Cercosporella pastinacae* Karst. is shown in Figure 3. The characters of the fungus and the symptoms of disease aid in the identification of

the disease. The minute spores of these fungi are borne on short stalks arising from the mycelium in the diseased areas of the leaves. Thus the spores are exposed to the weather by which they are spread for the distribution and progression of the disease. Moisture is essential to the fungus and to spore germination and infection. Thus, excessive wet weather in the presence of the fungus parasite can bring on an epidemic of disease and serious loss.

Bacterial plant diseases are represented notably by wilts and soft rots. Bacterial soft rot is common and destructive to parsnip roots. The diseased tissue of bacterial diseases is usually slimy and sticky. Most of the plant pathogenic bacteria are wound parasites. They may live in dead organic matter and only occasionally develop as parasites. These bacteria are rod-shaped and measure less than 1/25,000 of an inch long. The bacteria multiply by division, and spore production is usually absent in the plant parasitic forms. Some of the species are equipped with whip-like threads to provide motility. Transmission is by seed, cuttings, insects, water, etc. Bacterial plant diseases represent an important segment of food crop pathology, and several species yield to satisfactory control by antibiotic chemicals.

Mosaic, yellows and stunt are names commonly applied to plant virus diseases. Viruses are the simplest forms of living matter and occupy a position between inanimate substance and living organisms. Their composition combines protein and nucleic acid. The virus particles are extremely small; about a million of them can be contained in an average bacterium. Generally they cause chronic rather than fatal plant diseases, and parasitism is imperative to their existence. Infection involves the entire system of the diseased plant, and is extremely contagious. Spread is usually by insects, notably aphis and leaf hoppers. The aster yellows virus occasionally causes disease in parsnips, but its occurrence in lettuce and carrots can be serious. Virus diseases are especially important in crops propagated by cuttings, tubers and bulbs. Seed transmission is rare.

Nematodes represent another group of important parasites of crop plants. They are minute worm-like animals of borderline microscopic size. There are male and female kinds and reproduction is by eggs. Nematodes inhabit the soil. About fifty species among many thousands of different kinds of nematodes cause diseases in plants, and one of them, the northern root-knot nematode, causes an important disease in parsnips. Damage from nematodes is greatest in warm climatic regions or in greenhouses generally, yet serious nematode problems occur in cool climates. Roots and underground parts of plants are most commonly injured. Other parasitic nematodes attack stems, leaves and buds. Modern practice has accepted chemical soil fumigation for the control of the root-knot nematode. Soil heating is the universal method of control in greenhouses and chemical fumigation in the field.

The non-parasitic diseases can be as easily understood. Their origin can be simple, as the lack or excess of some particular plant nutrient in the soil or the excess or lack of some factor of the weather, as moisture, light, unfavorable temperature or soil reaction. The cause may be complex and not understood, requiring further study for more information. A particular variety of parsnip may have a genetic tendency for an abnormal state of growth, and the condition can be made worse by some specific factor of the environment. The same circumstances apply to parasitic diseases. Thus, the diagnosis of non-parasitic diseases proceeds from a knowledge of the weather, soil nutrients, etc., and an understanding of the environmental conditions of the plant in a state of disease and in a state of normal growth or health.

PARASITIC ROOT DISEASES IN THE FIELD

Bacterial Soft Rot. The bacterium *Erwinia carotovora* (Jones) Holland Fig. 4.

This disease is common to spring-dug parsnips. It follows damage from insect injuries, other root diseases, and injuries associated with the heaving of the roots and the exposure of the crowns to severe weather conditions, especially in winter. The soft wet rot begins in the injured crowns of the roots. Planting on well-drained land and protecting roots through the winter with a cover of hay, marsh grass or other mulch to prevent the heaving and exposure of the roots is recommended. The prevention of injuries and other root diseases is important to the control of bacterial soft rot (See Sunburn, Scald, p. 10).

Crown Gall. The bacterium *Agrobacterium tumefaciens* (E. F. Sm. & Towns.) Conn

The disease appears as rather hard tumors or galls of various sizes on any part of the root, sometimes even thicker than the root which bears them. It occurs on all vegetable root crops and has only rarely been seen on parsnips. The disease appears in low, wet areas in the field. Raised bed culture and planting on land free from this trouble is recommended.

Canker or "Sorehead". The fungus *Itersonilia perplexans* Derx Figs. 5, 6, 7.

The fungus causes disease in sunflower, chrysanthemum, wild parsnip, wild carrot and several other cultivated and weed plants. It causes one of the most serious diseases of parsnip roots.

The broad-shouldered Hollow Crown and All-America varieties are especially susceptible to this disease. Varieties with conical or rounded crowns like Tender-and-True and Model have some resistance. The dark

colored lesions about the crowns of the roots are invaded by other organisms, especially the soft rot bacterium *Erwinia carotovora*, giving the crowns an offensive, decayed appearance which our growers call "sorehead." Infection is not restricted to the crowns of the roots. The fungus also causes a spotting of the leaves. The growth of the organism and infection are favored by excessive and persisting moist and acid soil conditions, and prolonged, cool, wet weather.

Brownish discolored tissue is a feature of "sorehead." The decayed tissue may be soft due to the bacterial soft rot organism. Often it is firm and dark brown. The *Itersonilia* canker lesions often have a purplish shade of color, and the bacterial pathogen, *Pseudomonas pastinacae* Burkh., which produces this color in artificial culture, is invariably present. This bacterial pathogen follows injuries and is commonly present in "sorehead" in the autumn and spring seasons' harvests of roots. The decay in the crowns is firm and brown, and the progress of infection is slow in contrast to that of bacterial soft rot. Infection of the crowns by the bacterial pathogen is predisposed by the heaving of the roots and weather injury in the late winter season. (See Sunburn, Scald, p. 10.)

Cropping parsnips on well-drained land and on raised beds, especially liming the land for a pH reading of 7.0 is recommended if the soil reaction is less, and top dressing with lime after early July. Weed control is also important. Irrigation should be practiced with reason and only as necessary. The protection of the foliage with copper fungicides, as for the control of the common parsnip leaf blight diseases, aids in the control of root infection. Home-made Bordeaux mixture is preferred. The leaf spot phase of the disease appears first and supplies inoculum for root infection. Protection with fungicides should begin late in July.

Watery Soft Rot. The fungus *Sclerotinia sclerotiorum* (Lib.) DBy. Fig. 8.

The dead, diseased leaves lie prostrate over the crowns of the roots in the field late in the growing season and are overgrown with whitish mycelium and black sclerotia of the pathogen. Infection usually begins in the foliage and then follows the petioles into the crowns. The disease is serious in storage. Rotation of the land with less- or non-susceptible crops like beet, onion, cucumber, sweet corn, or forage crops is important. Culture on well-drained land and on raised beds is desirable, also on fields well exposed to good air movement. Protection of the green foliage with fungicide as for the control of the leaf blight diseases provides some degree of control. Calcium cyanamide (Cyanamid), 800 pounds per acre, applied to moderately moist land and then mixed with the soil by discing well in advance of seeding, i.e. three days for each 100 pounds of applied chemical and according to manufacturers' directions, is recognized as a helpful control measure.

Northern Root-Knot. The nematode *Meloidogyne hapla* Chitw. Figs. 4, 9.

This nematode, familiar to the growers, is of considerable importance on carrots and parsnips. The galls, or root-knots, render the roots unmarketable. Chemical fumigation of the fields in the autumn has provided good control for a period of two to three years. The treatment should be applied to the land after some incidence of a nematode infestation appears in the harvested roots. The soil fumigant is either EDB (Ethylene dibromide) or D-D (1,3-dichloropropene; 1. 2-dichloropropane). Also DBCP (1,2-dibromo-3-chloropropane) as emulsifiable concentrate or granules applied in the spring season is satisfactory. The manufacturers' directions for use and safety precautions must be followed. A custom operator can be engaged for the purpose.

Scab. The fungus *Streptomyces scabies* (Thax.) Waks. & Henrici Fig. 10A.

No important cases of scab on parsnip roots have been observed. This disease occurs occasionally on root crops of all kinds and can be important on potato.

Black Crown Rot. The fungus *Centrospora acerina* (Hartig) Newhall, Fig. 11.

The roots are rotted at the crown. The bases of the leaf stalks are rotted away. The disease is favored by prolonged wet weather, excessively wet conditions about the crowns, warm temperatures, and poor drying conditions. The disease occurs chiefly on roots in storage, and it is not common in Massachusetts.

The decay is firm and of a brownish-black color. The foliage and flowers of numerous ornamental, florist and vegetable plants, but not parsnip, are susceptible to infection. Black crown rot is important on parsley, carrot and celery and usually only after some period of storage. For control measures see Root Diseases in Storage, p. 11.

NON-PARASITIC ROOT DISEASES IN THE FIELD

Root Cavity Spot Fig. 12.

A brown and pink spot disease on parsnip roots was found on one farm in Essex County in 1956. Isolations yielded bacteria, sometimes the fungus *Fusarium* and other fungi. The spots are general on the roots, linear to elliptic, pale brown and sometimes pink with dark centers. Pits or craters in the tissue under the surface feature the disease and suggest maggot injury. There have been occasional further occurrences of the disease on parsnip roots in Massachusetts since the serious occurrence in 1956.

A similar disease has been observed on carrot roots in Massachusetts, and serious occurrences have been found on roots of the Waltham Hi-color variety. A comparable non-parasitic root spot disease of carrot was reported in California and attributed to abnormal oil production in the roots and to the enlargement and rupture of the oil ducts. The root cavity spot of parsnip and carrot in Massachusetts is not a parasitic disease, the organisms in the spots being secondary. A common bacterial isolate causes a slimy soft rot, and a species of *Fusarium*, another common isolate, causes a soft pink rot.

Studies of the disease on carrot show a marked variation in the prevalence of the disease among like sowings of carrots on different areas of land. In 1959 at Waltham it was more prevalent in the later spring season sowings of seed than in the earliest sowings of May 13. In 1959 the least amount of the disease occurred on land in vegetable culture for many years; the greatest amount in a barren silt and clay soil. These differences could not be explained by rapid analytical values of soil samples for soil reaction and major plant nutrients. In greenhouse experiments the disease was consistently greater in carrots from plots excessively watered during culture, greatest on plots leached with water before seeding, and less than both on plots fertilized with complete fertilizer before planting. The circumstances imply the importance of fertile soil in advance of planting as a measure of control.

Caution is advised with respect to artificial irrigation to prevent excessive leaching of soil fertility and to discourage infection of the cavities by secondary organisms.

Irregular Roots Fig. 13.

Misshapen and twisted roots result from over-seeding and crowded stands, and by stone and solid debris in the soil, physically interfering with the normal growth of the root. The land should be of a deep sandy loam and relatively free of solid material. Thin sowings are recommended to avoid pressure from crowding. If the stand is thick, it should be thinned. These features of the land and the stand of plants have no connection with forking or secondary root formation.

Growth Cracks Fig. 10B.

Cracking of parsnip roots is a trouble comparable in its origin to growth cracks in Butternut squash and tomato. Tissue callusing follows cracking, if the cracking does not occur too late in the growing season. It is caused by an abrupt change in the weather, e.g., drought followed by heavy rainfall after the middle of the growing season. Raised bed culture helps to prevent the trouble to some degree. An even, natural supply

of moisture or lacking it, some artificial irrigation, is important for the normal growth of roots and the prevention of the trouble.

Forking, Secondary Roots Fig. 14.

This serious abnormal root development is popularly called "crabs." The cause has been attributed to crowded stands, stone and gravel, compact and shallow soil, fresh manure, mechanical injury to the growing root tips, and to infestation of the roots by nematodes and larvae of the carrot rust fly. The varieties Tender-and-True and Model are not usually affected, while Ace, Hollow Crown, and especially All-America can be seriously affected. The resistant varieties, however, may sometimes show considerable forking.

There is considerable difference in the forking of parsnip roots among successive sowings of seed on the same land and on different planting sites, but no consistent difference between raised and ground level beds in the same area of culture and same time of planting. The harvests of successive years of culture on the same land show different incidences of forked roots. Forking appears early in the seedling stage of growth especially, but it also occurs later along the axis of the main root and at the growing point. The problem is not due to fungus, insect or nematode and it can occur in serious proportions in the absence of fresh manure. What makes a lateral root and what makes it fleshy? There is no good answer. Environmental growth conditions and plant nutrition added to a strong genetic tendency to fork in the variety, are involved.

Varieties having a tendency to fork should be avoided. Forking can be more prevalent on excessively wet than on relatively dry culture. The problem remains vague and requires study.

Sunburn, Scald Fig. 15, 16.

The heaving of over-wintered parsnip roots in the early spring season as the land thaws and freezes exposes the crowns to sunlight and extremes of temperature. The crowns are discolored. Reddish tints of color develop and deterioration follows. Bacterial soft rot, blue mold rot, and other forms of decay develop in the injured crowns. The excessive heaving of the roots is featured by short, stubby varieties with thick crowns, such as the variety Hollow Crown; or globose or broad roots, such as the varieties Round and Short Thick. Varieties with slender, tapering roots, such as the variety, Model heave the least or not at all.

The thawing and freezing of the land in the spring season can be prevented by hay mulches. The mulch is removed in the spring season progressively with the succession of harvest or digging periods. If the field is not mulched, harvest should begin early and be completed before the heaving is too extensive. Marsh hay available along the coastal areas makes a cheap acceptable mulch for over-wintering parsnips.

INDEFINITE DISEASES

Rusty Root (cause unknown) Fig. 17.

This term is used by growers for brown-colored blemished areas on the surface of the root. Several organisms have been recovered from these superficial rusty areas. Wet, heavy land appears to favor it. Attempts to produce the disease artificially have not succeeded.

ROOT DISEASES IN STORAGE

This category includes the following major diseases:

Gray Mold Rot, the fungus *Botrytis cinerea* Pers. ex. Fr.
Blue Mold Rot, the fungus *Penicillium* sp.
Watery Soft Rot, the fungus *Sclerotinia sclerotiorum* (Lib.) DBy.
Black Mold Rot, the fungus *Rhizopus nigricans* Ehr.
Black Crown Rot, the fungus *Centrospora* acerina (Hartig) Newhall
Bacterial Soft Rot, the bacterium *Erwinia carotovora* (Jones) Holland
Bacterial Brown Rot, the bacterium *Pseudomonas pastinacae* Burkh.
Figs. 4, 11, 18, 19, 20.

The storage cellar should be cleansed, then disinfected with 1 gallon of commercial grade formaldehyde (37%) to 49 gallons of water before the storage season. The entire interior of the storage cellar is wetted with the disinfectant, and the storage room is then sealed for 24 hours. Sulfur dioxide gas is also satisfactory. The fumigant is obtained by burning 5 pounds of brimstone sulfur to 10,000 cu. ft. of storage. The burning is done on a fireproof base or the ground floor of the cellar to prevent fire. This fumigant corrodes metal.

A better method is fumigation with formaldehyde gas generated by combining one pound of potassium permanganate crystals and one quart of commercial formaldehyde to 1,000 cu. ft. of storage. Containers of 25 gallons capacity to each 10,000 cubic feet are used. The required amounts of material are prepared for each container. The permanganate crystals are added to the formaldehyde in the pails beginning at the farthest pail and then to the others in the direction of the exit. Formaldehyde is not corrosive. The gas is confined for 24-48 hours.

The parsnips should be dug for storage late in the autumn season in prevailing dry and cold weather and before the land freezes. Only sound healthy roots should be stored; never bruised or damaged ones. The roots must be cold, not warm at harvest, and promptly removed to a cold air-circulated storage. The decline in the storage temperature after the

roots are placed in storage is important, and after the temperature has been lowered to 32°-35° F., it should be maintained. Moist, stagnant and warm air conditions and a relative humidity above 90% should not be tolerated. The condensation of moisture and abrupt changes in temperature should be prevented by forced air circulation. Fans or blowers are recommended for the purpose.

The fungicide Captan is registered for use on parsnip roots after harvest as an aid to the prevention of decay. Dusting the roots would be the logical method of application.

Mounds and pits for outside storage should be located on elevated areas that have not been planted to root crops and provided with openings or air ducts for aeration during the storage period. The mounds and pits are usually protected with a covering of hay or marsh grass (Fig. 21). A short cold storage period reduces the starch to sugar and enhances quality, sweetness and food value of the roots.

FOLIAGE DISEASES IN THE FIELD

The parasitic fungi involved are:

Cercospora pastinacae (Sacc.) Peck, Fig. 1.

Itersonilia perplexans Derx, Fig. 7.

Cercosporella pastinacae Karst. Syn. *Ramularia pastinacae* (Karst.) Vestergr., Figs. 2, 3.

Sclerotinia sclerotiorum (Lib.) DBy., Fig. 8.

Yellows. The virus *Chlorogenus callistephi* Holmes.

The leaf spot diseases are more or less similar, and identification is possible only by microscope. They ultimately destroy the foliage. The loss of the foliage from disease seriously impairs the quality and size of the roots. The *Itersonilia* canker fungus causes numerous small silvery spots in the foliage. The foliage diseases usually appear in August and early September. *Sclerotinia* foliage rot is quite distinct. The foliage, leaves, and stems, beginning with the oldest outside leaves, are rotted and fall prostrate to the ground over the crowns of the roots. Black fruiting bodies and white mold of the fungus develop among the decayed leaves. The crowns of the roots are infected and the roots rot. The spread of infection through the mass of roots can be considerable.

The leaf spot diseases are serious in wet seasons and on land with poor air and soil drainage. Parsnip fields are usually not sprayed or dusted unless the leaf spot diseases show a tendency to be progressive. Neutral copper, 50% active 2 lbs., 25% active 4 lbs. in 100 gallons of water, or Bordeaux 8-8-100, or copper dust 6-8% active are recommended. Applications are begun in late July or the first of August and continued through

the season to near harvest. This practice should be routine every year as insurance against infection. It is especially important in the control of the *Itersonilia* root canker disease.[1]

Yellows is uncommon on parsnip in Massachusetts. The disease can be serious on carrot, lettuce, China aster and many other cultivated and weed plants. The eradication of weed hosts of the virus and the treatment of the fields and borders with DDT insecticide when the leaf hopper vectors of the disease are noticed in July are recommended for control.

SUMMARY

DISEASE CONTROL MEASURES

Parsnips require a deep mellow soil relatively free of stone and hard debris. Culture on raised beds is best, and beds as high as 8 inches are ideal. Raised beds insure drainage of water, and good drainage is adverse to the root canker disease and to such physiological disorders as root cavity spot.

The soil should have a pH of at least 7.0 to help in controlling canker. If lime is required, it should be applied after plowing and thoroughly disced into the soil.

Since parsnips respond to high fertilizer applications, it is suggested that 1 ton of 5-10-10 or equivalent fertilizer per acre be broadcast over the soil after plowing. This fertilizer should be thoroughly and deeply disced into the soil and the field plowed a second time, preferably in an opposite direction from the first plowing. After the second plowing the field should be bedded without discing so as to prevent packing by the tractor.

Thin sowings to provide sufficient space for normal root growth will insure well-formed roots. Crowding in the row will produce flat-sided and rough roots. Thick stands produce excessive top growth which prevents the foliage from drying properly after rains or irrigation. Good light and air movement and quick drying discourage disease; thus excessive growth of a thick stand can encourage the leaf blight diseases. Dense growth also makes good protection with fungicides more difficult.

Forking or secondary root formation can represent a serious loss factor, or even a near total loss, if the sowings are limited to one piece of land and to a single planting. Forking varies widely in amount on different planting sites. If practical, more than one planting site at each sowing rather than one can be an advantage by contributing to a larger supply of normal saleable roots.

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[1]Maneb, zineb, and ziram are recommended for controlling carrot and celery foliage blight diseases. There is as yet, no official registration permitting the use of these fungicides on parsnip, and as a matter of protection from possible seizure of the parsnip crop because of illegal residues, only captan and officially exempt compounds such as copper fungicides can be recommended.

Model is the preferred variety of parsnip in New England. It has but a slight weakness for forking, in contrast to Hollow Crown and All-America which fork badly. Model is the best root for packaging. It does not heave out of the ground in the thawing weather of the spring season like the varieties with thick crowns. In the absence of heaving, the crowns are not damaged by light and cold weather, and there is no bacterial soft rot. Tender-and-True is similar.

Finally, protection of the foliage with fungicides every year is a requirement of good culture. The schedule of applications should begin in mid-summer and continue into October. The loss of root growth from foliage blight diseases can be significant. The *Itersonilia* canker fungus produces much of its inoculum for root infection in the foliage, and its control there with fungicides contributes to the control of root infection. Neutral copper or Bordeaux 8-8-100 is the preferred fungicidal protectant for combatting these diseases.

For winter storage and marketing, the roots are dug late in the autumn season in dry cold weather and before the ground freezes. Digging should be done under reasonably dry but cold soil conditions. The cold roots are topped in the field and removed promptly to cold, air circulated storage and stored at temperatures of 32°-35°F. and relative humidity of 90%. Vertical ducts or pipes distributed among the roots from bottom to top of mass, and forced air fanning, can be an advantage in the removal of excessive moisture in the mass and air, and a means of lessening loss from fungous decay. The roots are also stored in crates and piled 10 to 12 crates high. Air circulation with blowers or fans is required to maintain uniform temperatures. The cold cellar storage is preferred to outdoor pits and mounds. After five weeks of low temperature storage, the roots are sweet and of exceptional quality.

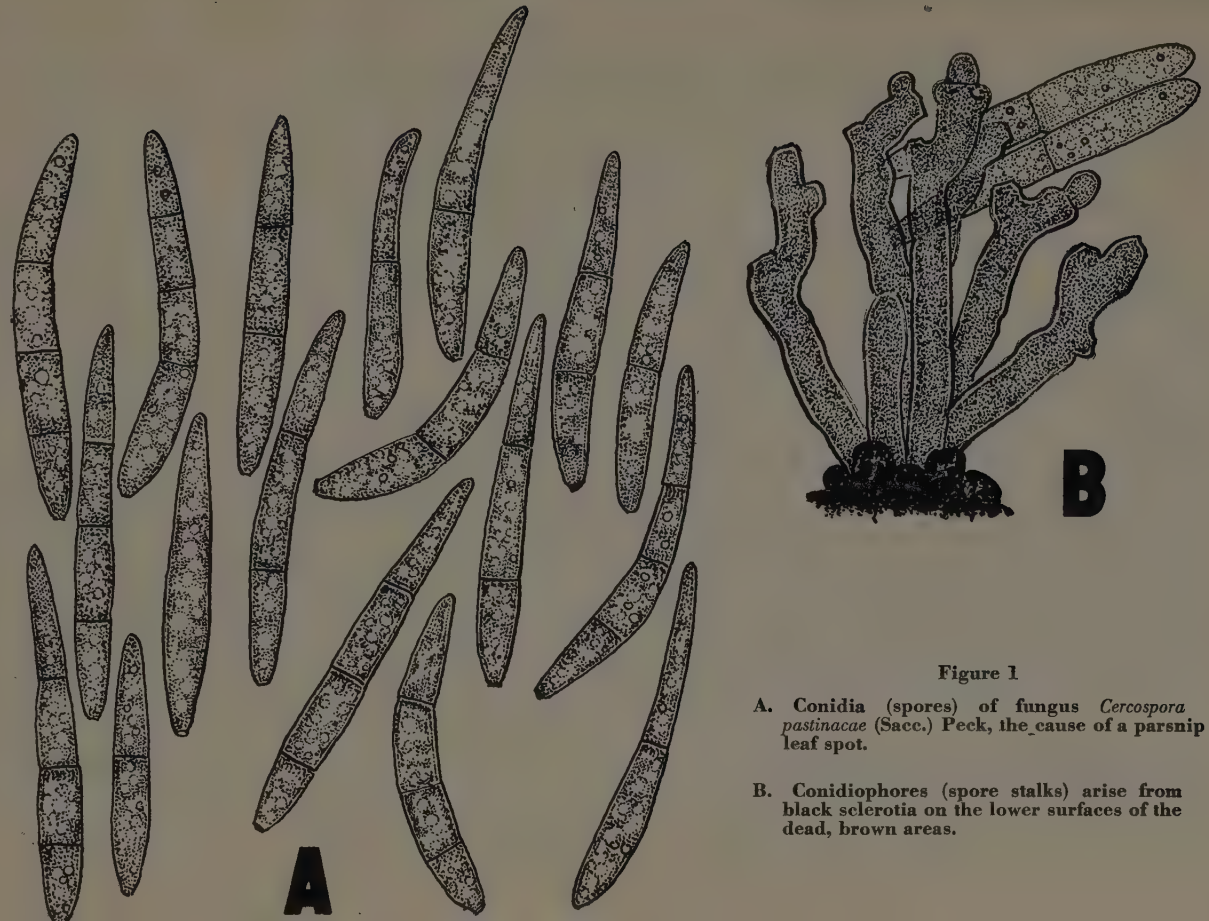

Figure 1

A. Conidia (spores) of fungus *Cercospora pastinacae* (Sacc.) Peck, the cause of a parsnip leaf spot.

B. Conidiophores (spore stalks) arise from black sclerotia on the lower surfaces of the dead, brown areas.

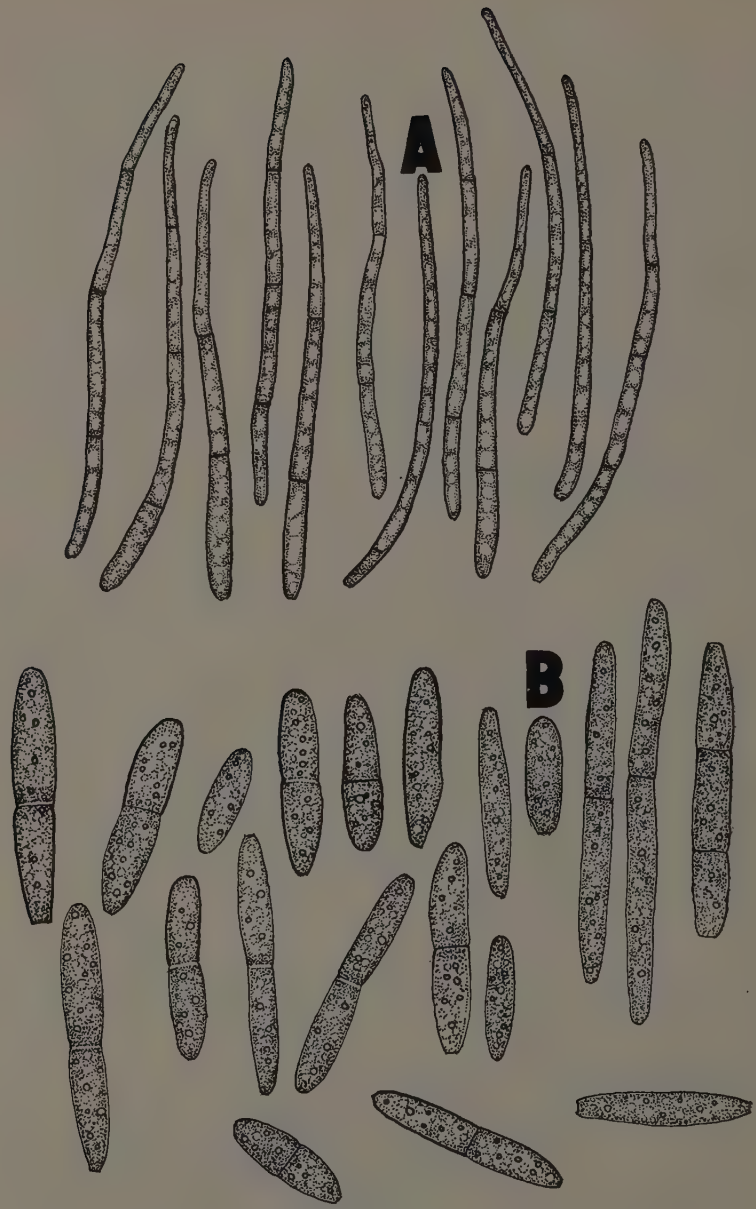

Figure 2

A. Conidia (spores) of fungus *Cercosporella pastinacae* Karsten (not *Cercospora pastinacina* Solh.), the cause of a parsnip leaf spot, borne on circular brown spots.

B. Ramularia-type conidia associated with parsnip leaf spot caused by the fungus *Cercosporella pastinacae* Karsten, not *Ramularia pastinacae* (Karsten) Vestergr. See Guba, Leaf Spot of Parsnip, Plant Dis. Rept., U.S.D.A., 39: No. 10, 747-748, Oct. 15, 1955.

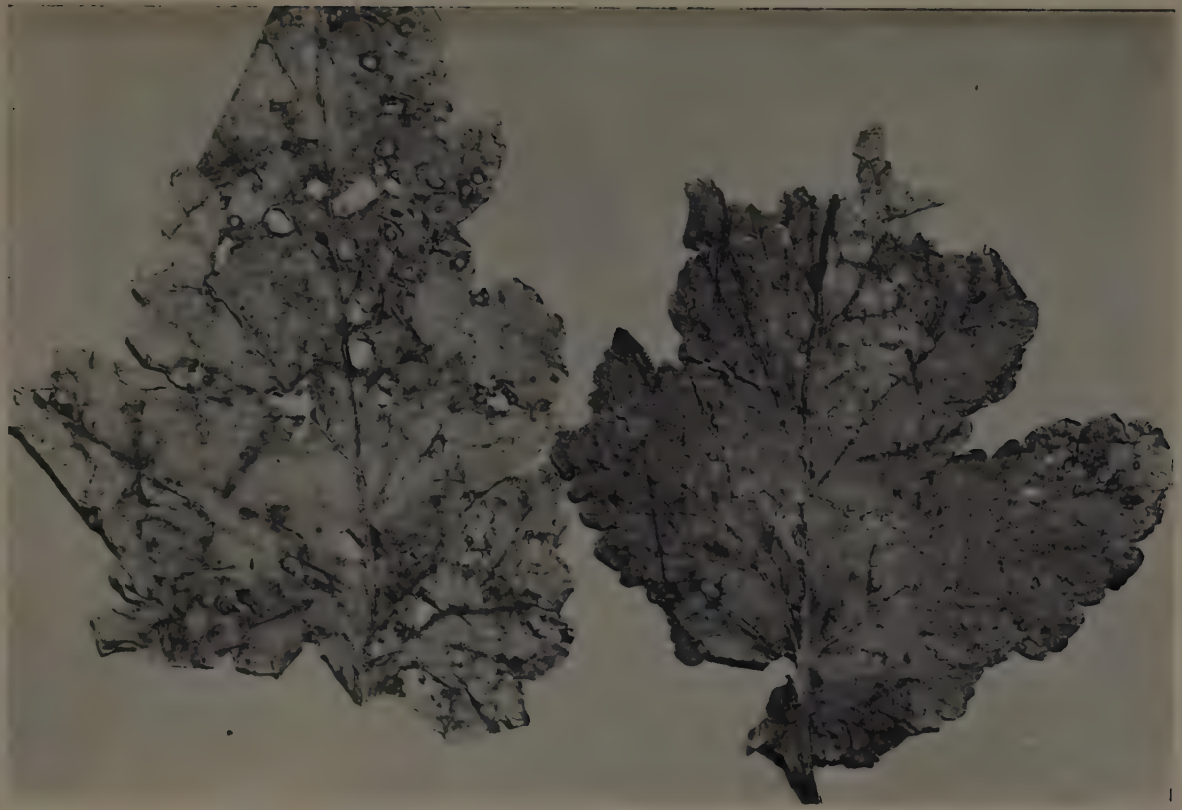

Figure 3. A leaf spot disease caused by the fungus *Cercosporella pastinacae* Karst.

Figure 4. Bacterial Soft Rot disease about the crown caused by the bacterium *Erwinia carotovora* (Jones) Holland. The parsnip root is also infested with the root knot nematode, *Meloidogyne hapla* Chitw. Note the knots about the periphery of the root.

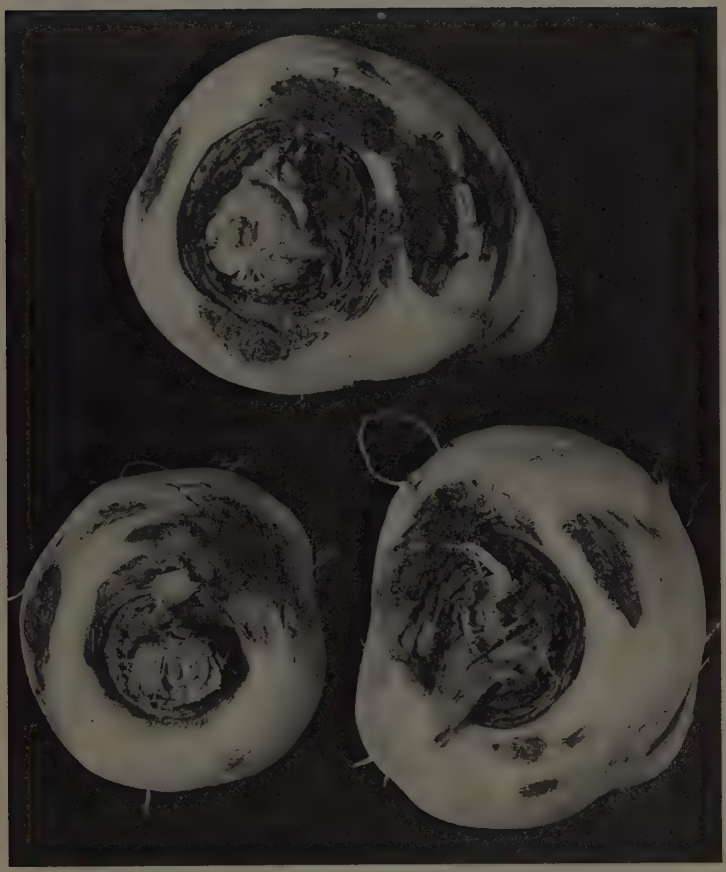

Figure 5. Canker of parsnip caused by the fungus *Itersonilia perplexans* Derx.

Figure 6. "Sorehead" of parsnip caused by a combination of primary and secondary fungi notably by *Itersonilia perplexans* Derx, followed by *Sclerotinia sclerotiorum* (Lib.) DBy., *Botrytis cinerea* Pers. ex Fr., *and Erwinia carotovora* (L. R. Jones) Holland.

Figure 7. Leaf spot caused by the fungus *Itersonilia perplexans* Derx. Result of inoculation of parsnip foliage with fungus from pure culture.

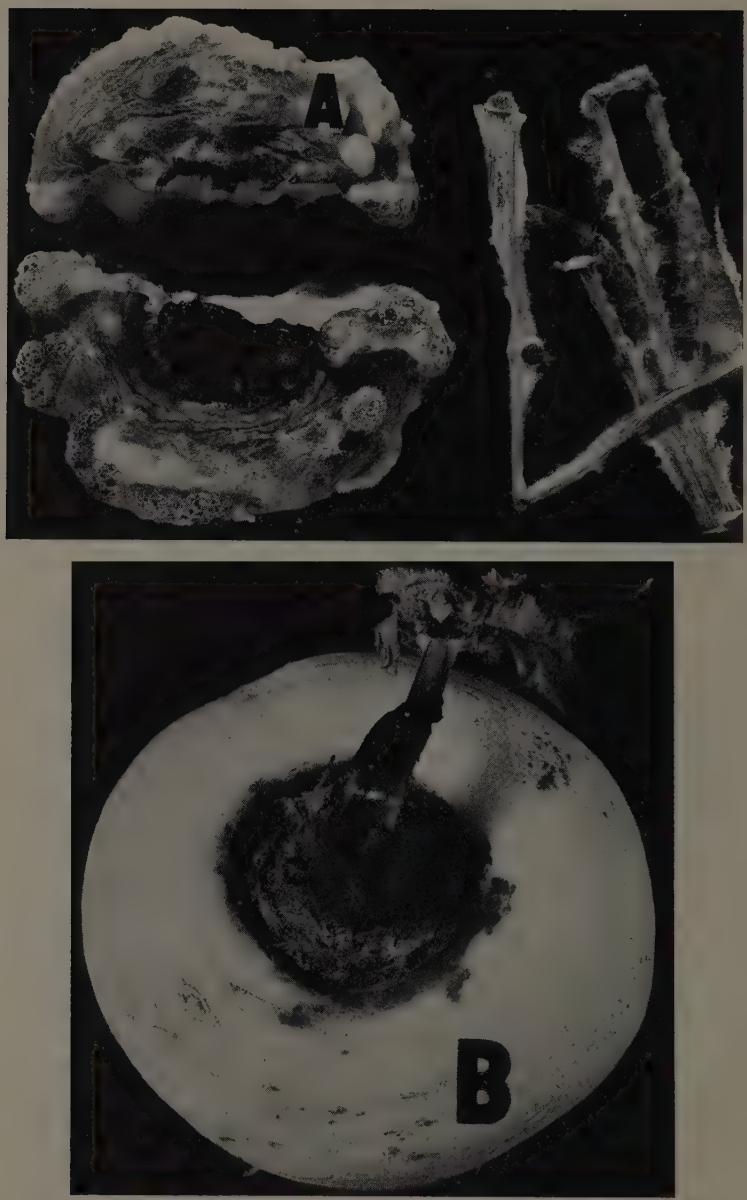

Figure 8. A. Parsnip crown and leaf petioles infected with fungus *Sclerotinia sclerotiorum* (Lib.) DBy. B. Invasion of parsnip crown by fungus from diseased leaf petiole in field before harvest in November.

Figure 9. Knots or galls on parsnip roots due to the root-knot nematode, *Meloidogyne hapla* Chitw. (See also Fig. 4)

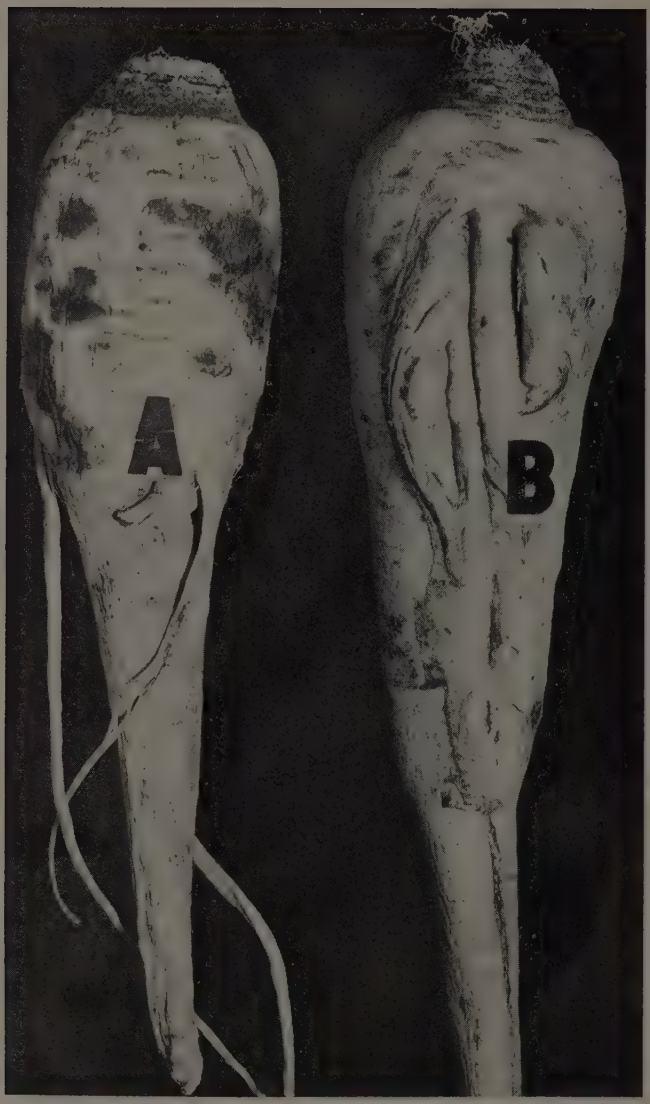

Figure 10.

A. Scab disease caused by the fungus *Streptomyces scabies* (Thax.) Waks. & Henrici.

B. Cracks or ruptures caused by heavy rainfall after drought, followed by growth calluses.

Figure 11. Black crown rot caused by the fungus *Centrospora acerina* (Hartig) Newhall. After C. M. Tompkins and H. N. Hansen, Hilgardia 19:396, 1950, Plate 6.

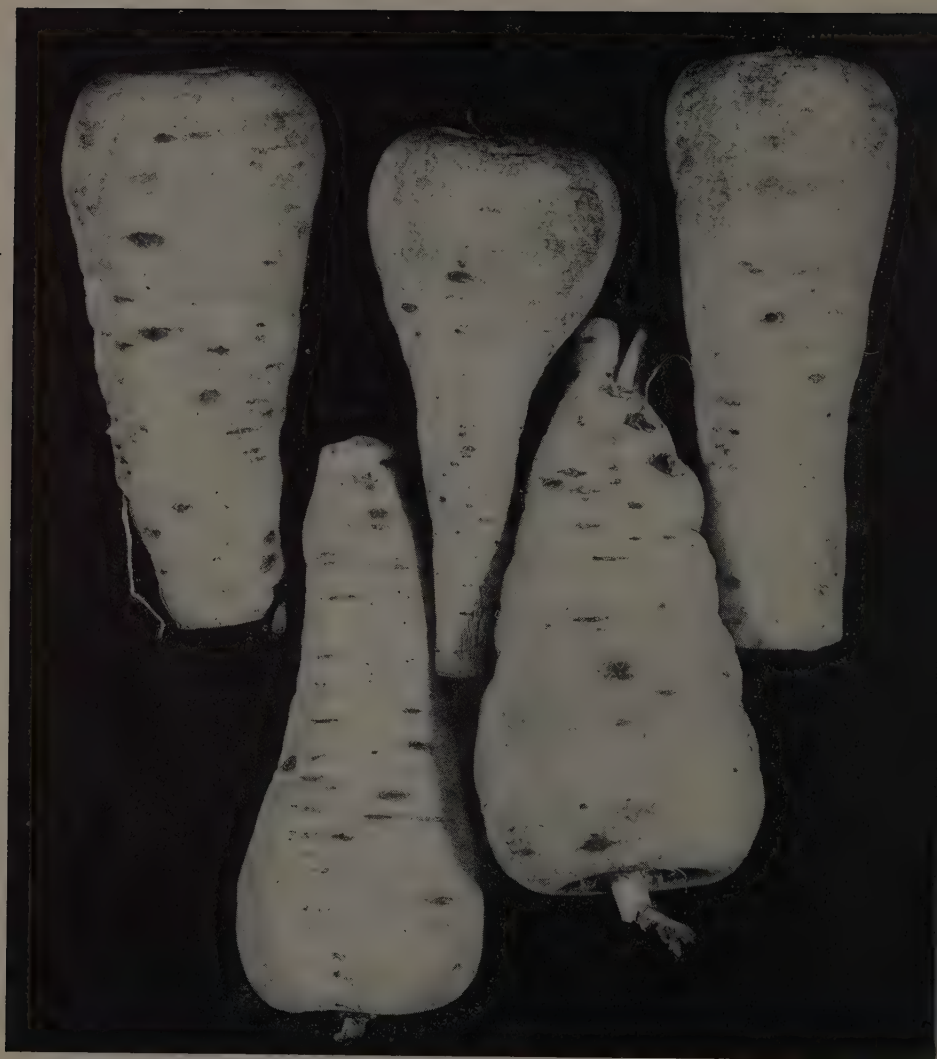

Figure 12. Parsnip root cavity spot, variety Hollow Crown.

Figure 13. Misshapen and distorted parsnip roots associated with crowded stands of roots and stony land.

Figure 14. Forking or secondary rooting; variety Hollow Crown.

Figure 15. Parsnip roots showing discoloration and deterioration at the crowns from heaving and exposure to sunlight and freezing temperatures in the early sprin g season.

Figure 16. Parsnips in spring season uprooted by freezing and thawing of soil. Exposed crowns are discolored and damaged by sunlight and decay organisms.

Figure 17. "Rusty root" disease; variety Hollow Crown.

Figure 18. Watery soft rot of parsnips from storage caused by the fungus *Sclerotinia sclerotiorum* (Lib.) DBy.

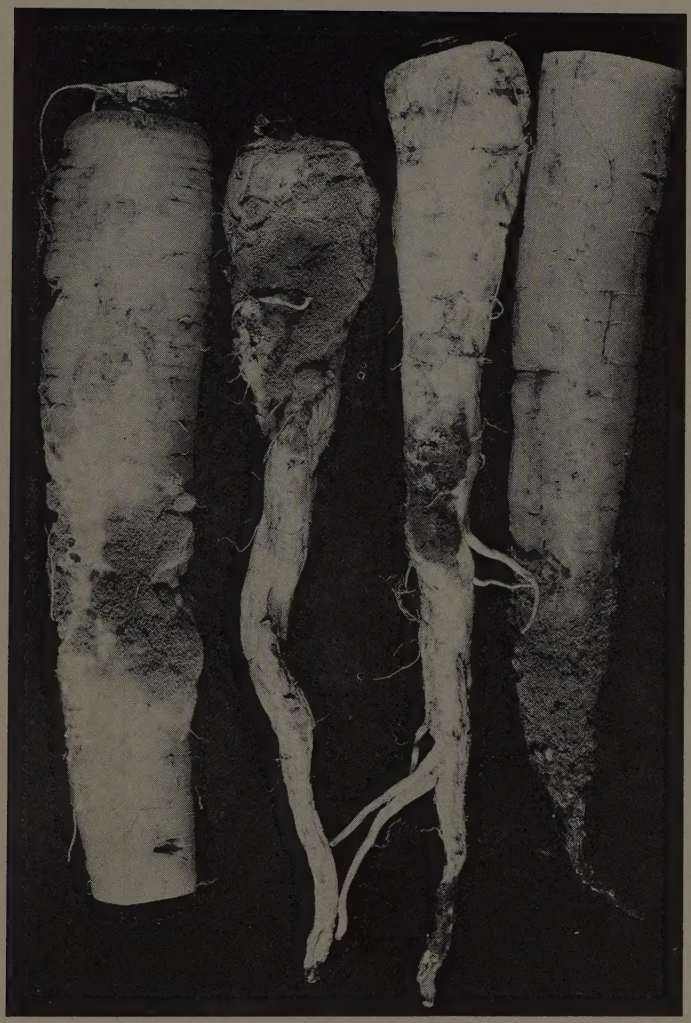

Figure 19. Gray mold rot in parsnip and carrot roots in storage caused by the fungus *Botrytis cinerea* Pers. ex Fr.

Figure 20. Black mold rot of parsnip caused by the fungus *Rhizopus nigricans* Ehr.

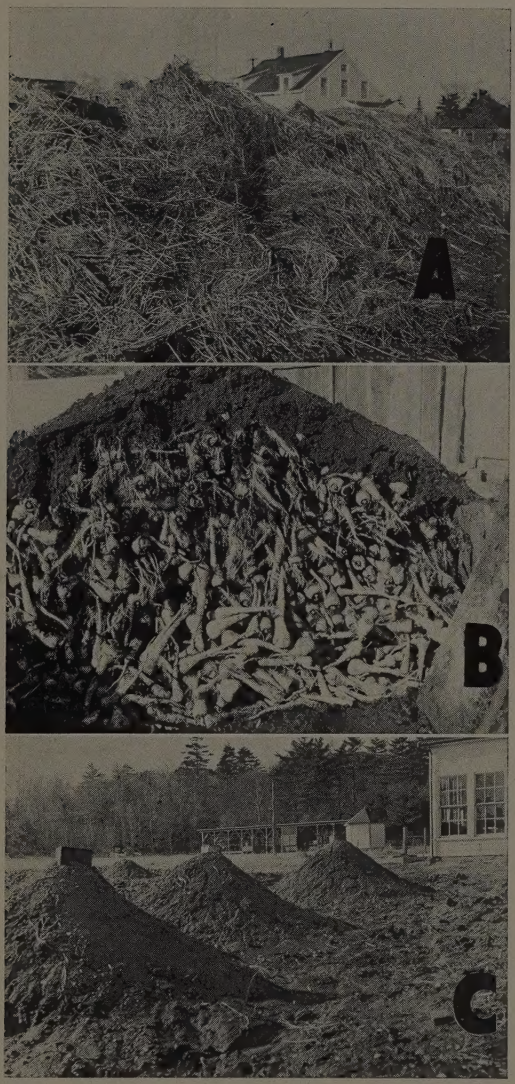

Figure 21. A. Outdoor parsnip mound protected with hay covering. B. Interior of mound showing mass of roots. C. Outdoor mounds of parsnips showing ventilators at the summits for ventilation.